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Soviet Chemical Equipment Purchases From the West: Impact on Production and Foreign Trade

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Summary

The USSR is highly dependent on Western chemical technology. During the period 1961-75, Soviet orders for Western chemical equipment and related process data amounted to at least $5 billion, more than 70 percent coming during the Ninth Five-Year Plan (1971-75). Contracts signed in the first two years of the 10th Five-Year Plan (1976-80) exceeded $3 billion, continuing the heavy emphasis on orders for the chemical industry.

Despite the large infusions of Western equipment and technology, the USSR remains an overall net importer of chemical products, and with few exceptions, it has not even become an important exporter of selected chemicals. Moreover, the chemical equipment received to date from the West does not appear to have led to a general improvement in Soviet technology for manufacturing chemical equipment. Gains in overall efficiency and product quality have come more slowly and probably at greater cost than anticipated by Soviet planners.

Nonetheless, Western equipment and technology are contributing substantially to Soviet output of several major chemical products and, in certain cases, are providing sizable savings in construction and production costs.

Western-equipped chemical plants accounted for:

- 40 percent of multinutrient (complex) fertilizers produced in 1975.
- 60 percent of polyethylene production in 1975.
- 75 to 85 percent of polyester fibers in 1975.
- 72 percent of new ammonia production capacity in 1971-75 and 85 percent of that scheduled in 1976-80.

Moreover, because most of the purchased capacity of recent years is not yet in production, many benefits lie ahead.

Economies in construction and operation of chemical plants stem from shorter construction periods and the use of more economical processes. Western-equipped plants in the USSR generally are completed three to five years after orders are placed, compared with an average of eight years for all

Soviet chemical plants. By incorporating technology developed in 1960s that revolutionized the ammonia industry in the West, Western-supplied ammonia plants have substantially cut Soviet production costs. During 1971-75, average unit production costs for Soviet ammonia fell by 8.5 percent as a result of introducing the new installations. Such plants use only about 5 percent of the electric power and one-third or less of the workers required per metric ton of output in existing Soviet-designed plants. Compared to older Soviet plants, savings of up to 30 to 40 percent in unit investment costs are possible.

Soviet construction and operation of many imported chemical installations still suffer from poor planning, inferior management, and inadequately trained or indifferent workers. The likely continuation of these deficiencies will prevent the USSR from realizing the full potential of its huge purchases of Western chemical technology.

Because domestic requirements are growing rapidly, few dramatic examples of a turnaround in foreign trade in chemicals have resulted from equipment purchases. However, Soviet orders of chemical equipment placed between 1974 and mid-1977, which often were associated with long-term compensation (product buy-back) agreements, will contribute to a sharp increase in Soviet chemical exports in 1980 and beyond. Sales of ammonia under such agreements will be an important destabilizing factor in world ammonia markets in the 1980s. Apart from their role in stimulating Soviet chemical exports, the compensation agreements almost certainly are permitting the chemical industry to develop at a rate that could not otherwise be sustained by the USSR.

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PREFACE

For more than a decade the Soviet Union, in an effort to bring its large but backward chemical industry up to modern standards, has invested heavily in purchases of Western equipment and know-how. This report will examine the pattern of Soviet purchases of chemical equipment in the Ninth Five-Year Plan (1971-75) and provide some observations on the contribution of these and earlier purchases to output and efficiency of the Soviet chemical industry. Because many of the purchases made in 1974 and 1975 are not yet on stream, judgments concerning the net benefits of orders through 1975 must be tentative. An appendix provides a list of individual contracts for purchases of chemical equipment and technology from non-Communist countries during 1971-75.

Soviet Chemical Equipment Purchases From the West: Impact on Production and Foreign Trade

Background

The technical backwardness of important sectors of its chemical industry has been a major factor in the USSR's heavy reliance on Western equipment and related process data.[1] In 1958, when former Premier Khrushchev announced a comprehensive program to expand and modernize the Soviet chemical industry, it was a relatively obsolete structure, producing mainly basic chemicals and simple fertilizers. The Khrushchev program called for a rapid increase in the production of synthetic materials (plastics, manmade fibers, rubber), the adoption of improved processes, and the use of new, cheaper raw materials. These goals reflected developments then occurring in major Western chemical industries, which had grown rapidly in the 1950s and accelerated even more as consumers became increasingly aware of the vast potential of chemicals to provide new, economical materials and to replace metals in a host of industrial and everyday applications.

The rapid development of Western chemical industries was facilitated by the increasing availability of petrochemical raw materials, major changes in technology, and the achievement of substantial economies of scale. By the last half of the 1960s, more than 90 percent of organic chemicals in the United States and more than 80 percent of those in the United Kingdom and West Germany were derived from oil and gas. In the USSR in 1960 more than 50 percent of the raw materials used to produce organic materials were derived from coal, and a substantial portion came from edible raw materials such as potatoes and grain.

The Soviet chemical industry did, however, grow rapidly in the 1960s, albeit from a low base and with substantial shortfalls in plans for synthetic materials and fertilizers. Although the number of scientific research institutes in the Soviet chemical industry rose from 24 to 40 during 1959-65 and expenditures for chemical research more than doubled, the USSR was unable to reduce the technological gap with the major Western chemical producers. The problem appears to have been more the industrial application of the results of Soviet research than the basic research itself.

Sharp Increase in Equipment Orders

The chemical industry has been among the most favored sectors of the Soviet economy with respect to orders of Western equipment and technology.[2] Soviet purchases of chemical and related equipment from non-Communist countries in 1961-75 were at least $5 billion.[3] Almost three-fourths of the total was bought during the Ninth Five-Year Plan (1971-75). Annual orders of chemical equipment, which had averaged $140 million in 1961-70, jumped to more than $700 million per year in 1971-75; orders exceeded $1 billion both in 1974 and 1975. The value of equipment and technology ordered in 1971-75 ($3.6 billion) would be equivalent to between one-fifth to one-fourth of Soviet invest-

[1] For an interesting review of the historical development of the Soviet chemical industry, see Ronald Amann, chapter 6 of *The Technological Level of Soviet Industry*, edited by R. Amann, Julian Cooper and R. W. Davies, Yale University Press, New Haven and London, 1977; also useful is Francis W. Rushing, "Soviet Chemical Industry: A Modern Growth Sector," *Soviet Economy in a New Perspective*, pp. 535-557, printed for the use of the joint Economic Committee, Congress of the United States, 14 October 1976.

[2] The terms "orders" and "purchases" are used interchangeably in this report and should not be equated to actual imports for a given period. For details on Soviet orders in 1971-75, see the appendix.

[3] This figure is based on data believed to cover the great preponderance of Soviet chemical equipment orders in the 15-year period. It excludes the value of contracts for which such information was not reported and could not be reliably estimated.

Table 1

USSR: Orders of Chemical Equipment, by Type, From Non-Communist Countries

Types of Plants and Equipment	1971	1972	1973	1974	1975	1971-75	
	Million US $						Percent
Total						3,632	100.0
Agricultural chemicals and related facilities	22.0	0	28.9	786.2	697.0	1,534	42.2
Chemical fibers	13.5	123.8	127.9	85.4	364.1	715	19.7
Petrochemicals and related equipment [2]	29.0	25.0	58.7	0	203.9	317	8.7
Plastics and plastics processing	20.6	94.1	162.4	150.9	83.1	511	14.1
Rubber and rubber products	0.8	17.4	12.5	108.6	139.7	279	7.7
Other chemical equipment and technology	1.7	1.7	38.0	109.0	125.6	276	7.6

[1] Including equipment for production of intermediate chemicals used in manufacturing the cited products.

[2] Partial listing only. Information on purchases of other petrochemical installations is included with the data on the various product sectors that use petrochemical feedstocks.

ment in equipment for the chemical industry in that five-year period.[4] Actual deliveries and hence payment for a substantial share of the 1971-75 orders, however, would occur after 1975.

Starting with a polyethylene plant in 1972, Soviet purchases of chemical equipment have increasingly been associated with product buy-back or "compensation" deals. Under such arrangements, Western firms (not necessarily the equipment suppliers) agree to long-term purchase of Soviet products that are usually made in the facilities employing Western equipment. The compensation deals provide hard currency earnings with which the Soviets repay Western credits that help finance their equipment purchases.

Chemical equipment obtained from the West consists mainly of complete installations and assemblies, which require substantial leadtimes. Deliveries are generally completed two to three years after orders are placed. The large orders in 1974 and 1975 thus were in the main not reflected in data on Soviet imports through 1975.[5]

Soviet purchases of Western chemical equipment during the 1971-75 period probably exceeded initial Soviet intentions, reflecting the failure of domestic and East European manufacturers to meet supply commitments. In addition, Soviet agricultural problems evidently stimulated additional orders of fertilizer-producing equipment starting in mid-1974. Production shortfalls in chemical equipment occurred as early as 1971 and worsened throughout the five-year period. Production in 1975—771 million rubles[6]—was only 82 percent of the original plan. East European suppliers delivered less than

[4] The estimate is based on an unweighted dollar-ruble ratio of 2.6:1 (1972 dollars) that was derived from a fairly small sample of Soviet and US chemical equipment. Soviet chemical-petrochemical investment in 1971-75 (in January 1969 rubles) totaled 15.73 billion rubles, of which more than one-third went for equipment.

[5] The USSR also exports chemical equipment but such sales are substantially less than its purchases. Soviet chemical equipment exports in 1971-75, mainly destined for Eastern Europe, were valued at 323 million rubles. The ruble value would equate to about $419 million if calculated at official exchange rates, but little, if any of these sales would involve hard currency.

[6] This figure represents the value of Soviet-reported production of chemical equipment plus equipment for processing polymeric materials. The Soviet definition of chemical equipment used in production statistics excludes pumps, compressors, and certain other components of chemical plants.

Table 2

Soviet Chemical Equipment Orders Placed With Non-Communist Countries [1]

	1971-75		1971	1972	1973	1974	1975
	Percent	Million US $					
Total	100.0	3,631.7	87.6	262.2	428.4	1,240.1	1,613.4
Italy	26.4	958.8	0	66.0	45.0	192.0	655.8
France	22.0	799.1	2.7	23.3	98.4	352.5	322.2
West Germany	17.5	635.5	16.9	132.1	122.0	162.2	202.3
United States	14.3	519.6	4.8	12.1	67.8	353.4	81.4
Japan	12.3	445.7	46.6	21.1	12.9	69.8	295.2
United Kingdom	7.0	252.6	16.6	0.5	82.3	110.1	43.1
Others [2]	0.6	20.5	0	7.1	0	0	13.4

[1] Data are based on more than 110 orders (see the appendix). For perhaps 10 orders of known value, available information was insufficient to allocate contract shares to subcontracting firms from countries that differed from the country of the major contractor. In such cases the full value was ascribed to the country of the major contractor. Because of rounding, components may not add to the total shown.

[2] Including Switzerland, Belgium, and Austria.

72 percent of the volume initially scheduled for the 1971-75 period.[7]

Structure of Orders and Suppliers

Large, unsatisfied requirements of industry, agriculture, and the consumer appear to underlie the bulk of Soviet chemical equipment orders. Agricultural concerns are clearly reflected in recent purchases for the chemical industry. On a value basis, more than 40 percent of the 1971-75 orders for Western chemical equipment and related facilities consisted of installations for production, storage, and handling of fertilizers (table 1); more than 95 percent were placed in 1974 and 1975 alone when contracts for 12 ammonia plants and four urea fertilizer plants were concluded.[8]

The manmade fiber sector accounted for 20 percent of total chemical equipment orders from the West in 1971-75. Purchases were largely for equipment to produce polyester fiber, polypropylene, cellulose triacetate, and intermediates used in making nylon and other synthetic fibers (see the appendix). Installations for producing polyethylene, polyvinyl chloride, and polystyrene were among the orders for the plastics industry. The Soviets also purchased equipment for processing plastics, but their processing capacity may not yet be sufficient to handle the large volume of plastics that will become available in the next two or three years. Purchases for the rubber industry included automated installations for manufacturing tires and industrial rubber products.

Italian firms were favored in Soviet chemical equipment orders placed in 1971-75, accounting for about one-fourth of the total contract value (see table 2). Probably contributing to this success was the willingness of Italian firms to accept product buy-back arrangements, especially those involving sales of equipment for producing urea fertilizers and fiber intermediates. US firms, which ranked fourth, accounted for more than 14 percent [9] of the orders, largely by winning contracts for four ammonia plants, an acetic acid

[7] Soviet imports of chemical equipment from East European countries in 1971-75 totaled 930 million foreign exchange rubles compared with planned imports of 1.3 billion rubles.

[8] The emphasis on agriculture continued after 1975. Soviet orders from Western firms in 1976 to mid-1977 included 15 ammonia plants, three urea plants, numerous complex fertilizer installations, and a potassium chloride crystallization unit. In addition, six urea plants that apparently will be based on Western technology were ordered from Czechoslovakia.

[9] The US share excludes contracts won by foreign affiliates of US firms and some sales of chemical technology for which contract values have not been announced.

plant, and facilities to handle and store fertilizer, all of which involved US Export-Import Bank credits. Deliveries against these orders were small through 1975, and US firms accounted for only 4 percent of actual Soviet chemical equipment imports from the West in 1971-75. The US share was growing, however, increasing from only 0.3 percent in 1971 to 8.1 percent in 1975, and rose again in 1976. Japan and the United Kingdom ranked after the United States in Soviet chemical equipment orders placed in 1971-75. Japanese firms will supply several ammonia plants while British equipment will be used mainly to produce tires, industrial rubber goods, and manmade fibers.

A Continuing Market for Western Chemical Equipment in the 10th Five-Year Plan

During the current Five-Year Plan (1976-80) the chemical industry will remain one of the fastest growing of all Soviet branches, with output scheduled to increase by 63 percent over 1975. Heavy reliance on Western technology will continue. According to the Soviet Minister of the Chemical Industry, L. A. Kostandov, Western equipment valued at $7 billion is to be imported to support chemical targets under the current five-year plan. A substantial part of the total—perhaps $2 billion—represents orders placed before 1976 to allow leadtime for manufacture, delivery, and assembly of the equipment. Large additional orders in 1976-77—an estimated $3.4 billion—continued the heavy emphasis on equipment for producing fertilizers and synthetic materials, The remaining contracts, worth about $1.6 billion, should have been signed by the end of 1977 to measurably affect chemical output through 1980. The Soviet failure to conclude the additional chemical equipment contracts may have reflected the shortage of hard currency in the USSR and the reluctance of Western firms to accept further buy-back arrangements. An additional reason could be the Soviet campaign to reduce the number of unfinished construction projects. Domestic resources needed for existing chemical projects (construction materials, experienced construction labor, infrastructure) may already be strained.

Nevertheless, some sizable Soviet orders are likely in the near future. Within the past year, the Soviets have been seeking equipment or technology for: petrochemicals used in producing synthetic rubber, plastics, and detergents; tires; glass fiber; pesticides, especially fungicides and herbicides; and potash. US firms have been among Western companies involved in these negotiations. Prospects appear only fair, however, for major US participation in most of these projects because of the reluctance of US firms to accept long-term product buy-back agreements or to provide competitive financing.

Filling Soviet Needs

Problems of the Soviet Chemical Industry

The heavy reliance on Western chemical technology partly reflects Soviet inadequacies in the development of many chemical processes and products and partly the difficulties in converting promising scientific discoveries into commercial-scale production. In the 1950s and 1960s, Soviet attempts to develop improved processes or equipment for a number of important chemical products—ammonia, acrylonitrile, caprolactam, polyethylene, and others—resulted in high-cost, relatively low-volume installations that were obsolete by world standards by the time they were commissioned.

A few excerpts from a Soviet article published in mid-1964 illustrate the severity of the problems encountered at a Soviet-designed acrylonitrile facility [10] commissioned in mid-1963.

> Capital investments for building the raw materials shops amounted to 31.4 million rubles . . . . an additional 16 million rubles was spent on the acrylonitrile projects during startup and tuning operations. [The high startup costs, equal to half the initial investment, were said to result from required changes in equipment.]
>
> It [the acrylonitrile facility] operated 112 out of 364 days, although not continuously.

[10] Acrylonitrile is an intermediate, the uses of which include production of acrylic fibers, plastics, and synthetic rubber.

The other 252 days were spent on repairs, reconstruction and replacement of equipment.

Output is still negligible. In May 1964 [nearly one year after commissioning], output was measured only in tons. Each ton cost a pretty penny. In June more was produced but it was substandard.

In the design institute the designers wait for the chemists to resolve the problem, while the chemists wait for the designers.

Given such problems experienced with Soviet-designed equipment, it is not surprising that in 1965 the USSR ordered an acrylonitrile plant from Japan.

Soviet delays in commissioning an experimental industrial unit for continuous production of staple polyester fiber from terephthalic acid[11] may be a factor in recent Soviet negotiations to purchase a huge polyester fiber complex in the West. The experimental installation, originally scheduled for commissioning at Mogilev in 1973, was put into operation in 1976. Inadequate process development and poor equipment design were blamed for the delay.

Although substantial efforts are directed at duplicating Western work and the sales of Soviet chemical technology to date have been rather negligible, Soviet chemical researchers appear capable of developing innovative process technology and new or improved chemical materials.[12] Soviet licenses issued to Western firms in the last four or five years, a few of which were developed in cooperation with foreign firms, include process technology for the following products or applications: polyethylene (high-pressure process), polycarbonate resins, polyisoprene rubber, butylated hydroxy toluene (an antioxidant), FTOROFUR (an anticancer preparation), and chemical disposal of industrial wastes.

As yet, the foreign licensees are not known to be using the Soviet processes. In at least some cases, further work by the licensees probably will occur before commercial-scale production facilities are built. To speed commercialization of future Soviet laboratory discoveries, the USSR may increasingly seek Western assistance for this traditionally weak link in Soviet chemical development.

East European Inability To Fill Soviet Needs

Despite growing capabilities to supply certain types of chemical equipment and related technology, Eastern Europe has not been able to fill the gap between Soviet production and requirements in this area. The main East European contribution has been to Soviet production of basic chemicals and fertilizers. Technology required for such production generally is less sophisticated than that used in the petrochemical and synthetic materials complexes equipped by the West.

Equipment supplied by Eastern Europe has, however, had a significant impact on Soviet chemical output in selected areas. In 1975, one-fifth of the sulfuric acid,[13] one-fourth of the ammonia, and two-fifths of the urea produced in the USSR came from plants equipped by Eastern Europe. Soviet imports from Czechoslovakia have included ammonia and urea installations; East Germany has supplied plants producing caustic soda, hydrochloric acid, nylon, polyvinyl chloride, and other chemicals; and Poland's contributions have included 27 sulfuric acid plants and several phthalic anhydride units. Not all the chemical technology provided by Eastern Europe, however, is of Communist origin. Western technology is included in at least some of the sulfuric acid installations provided earlier by

[11] The process apparently resulted from Soviet – East German cooperation. In the West, terephthalic acid has been competing to become the major polyester intermediate in place of dimethyl terephthalate (DMT). Although DMT still is the main intermediate used for this purpose, cheaper Western processes for terephthalic acid have recently been developed that may give the latter an advantage in future polyester plants.

[12] Soviet research that could lead to technological advances includes work on obtaining proteins from hydrocarbons and other organic materials, high-temperature plastics, high-performance composite materials, new or modified fibers catalytic systems that could reduce unit energy inputs in production of chemicals, and plasmochemical processes that may offer more economical routes to production of acetylene, ethylene, nitrogen fertilizers, and other products.

[13] A few sources attribute an even larger share—one-third of Soviet output of sulfuric acid—to plants equipped with East European (Polish) equipment.

Poland. Technology for Polish molding machines supplied to the USSR was licensed from a West German firm. Six urea units ordered by the USSR from Czechoslovakia in 1976 apparently will incorporate Dutch technology.

Moscow announced its intention to increase purchases of East European chemical equipment by 170 percent during the 10th Five-Year Plan. Part of the increase is believed to reflect the inflation in equipment prices in recent years. East Germany, which is to provide equipment valued at about 1 billion rubles, will be the major Communist supplier; its exports to the USSR will include installations for production of polyethylene, caprolactam, and nylon. Deliveries from Poland are to include 21 additional sulfuric acid plants with a total annual production capacity of 10 million tons; Czechoslovakia will ship to the Soviet Union steam-reforming units for ammonia plants and centrifugal compressors. East European chemical equipment manufacturers are unlikely to meet all these ambitious targets, however, if their performance during the Ninth Five-Year Plan (1971-75) is taken as a guide.

Significance of Equipment Purchases—Now and Later

It is clear that shortcomings in construction and operation of the imported chemical installations have denied to the Soviet Union the full potential benefits of technology transfer. The contact with Western chemical technology appears to have led to little progress in upgrading this technology by Soviet scientists and technicians. Nor has it yet stimulated many unique Soviet contributions in this field or resulted in a marked improvement in Soviet capabilities to manufacture chemical equipment.[14]

The direct contribution of Western equipment and technology, however, has been substantial, especially its role in boosting output of many key chemical products and, in some cases, in permitting major savings in unit investment and production costs, including economies in labor inputs. Moreover, the sharp upsurge in equipment orders in recent years indicates that the major impact of the purchases lies ahead. In addition to further benefits stemming from reduced costs and increased efficiency, the recent purchases foreshadow improvements in product quality and assortment and a steep rise in Soviet chemical exports, in part the result of product buy-back agreements.

Although available information does not permit an examination of all facets of the chemical technology transfer, the examples cited below support the preceding generalizations. They deal principally with the actual or potential contributions of Western chemical equipment but also illustrate some of the problems that prevent optimum Soviet use of foreign technology.

Contribution of Western Equipment to Production or Capacity

Fertilizers and Related Intermediates

Western equipment and technology have made major contributions to Soviet production (or production capacity) of urea fertilizers, complex (NPK) fertilizers, and ammonia—a key input for nitrogen fertilizers. At least 1 million tons of urea fertilizer capacity purchased from Western firms was in operation by 1970, providing perhaps 30 percent of total Soviet urea output that year.[15] Western urea technology will be even more in evidence in the USSR during 1976-80. Seven urea plants ordered from Western firms through mid-1977 and scheduled for operation by 1980 could provide 3.5 million tons of production capacity. In addition, Czechoslovakia is to provide six urea units that will utilize Western technology. The Czechoslovak installations will have a total annual production capacity of about 2 million tons but only half of this capacity is scheduled for installation by 1980. The Soviets appear to be planning a production increase of about 3 million tons of urea during 1976-80.

[14] The Soviet Union plans, however, to build the world's largest nitric acid plant, as well as an ammonia plant with twice the unit production capacity of those purchased to date. Western cooperation and/or supply of at least some equipment is likely if these plans materialize.

[15] This is a minimum estimate. A number of urea installations supplied to the Soviet Union by Czechoslovakia had the same unit capacities as those supplied by a Western contractor and may have incorporated some Western technology.

Even with the customary construction delays, plants incorporating Western technology should provide most of the increment.

Soviet reliance on Western technology has few examples as dramatic as that involving ammonia, a product that can serve as either an intermediate for nitrogen fertilizers or directly as a liquid nitrogen fertilizer. Installations based mainly on Western technology provided an estimated 3.25 million tons or 72 percent of Soviet ammonia production capacity introduced in 1971-75.[16] Although the contribution to production was more modest—about 17 percent of the 51 million tons of ammonia produced in the USSR in 1971-75 originated in Western-equipped installations [17]—large plants based at least in part on Western technology are scheduled to provide 60 percent of Soviet production of ammonia in 1980. These include at least 26 more large ammonia installations planned for initial operation in 1976-80. Although Soviet and Czechoslovak equipment will be used in certain of these, all the installations apparently will use some Western technology or equipment. The 26 plants alone could provide about 85 percent of the 13.4 million tons of scheduled new ammonia production capacity.

These impressive statistics do not, however, mean that Soviet assimilation of Western ammonia technology has been on schedule. One of the smaller Western-based units, located at Cherkassy, was at least two years late in coming on stream. A few large units that will at least partially depend on Western technology but incorporate a substantial amount of Soviet or Czechoslovak equipment apparently have had construction delays of one year or longer. Large Western-supplied ammonia installations at Nevinnomyssk in the Caucasus and Severodonetsk in the Ukraine experienced frequent breakdowns during at least part of their first year of operation. Distribution problems affecting natural gas, the major Soviet feedstock for ammonia, have caused at least temporary underutilization of some imported installations. Such problems are not uncommon in the West. Moreover, the Soviet delays in commissioning ammonia plants apparently are less serious than in the past. The construction period required per thousand tons of new ammonia capacity reportedly has been reduced to 45 percent of its former level. Finally, production of ammonia-dependent nitrogen fertilizers in 1975 exceeded the original goal by 500,000 tons of nutrient, whereas goals were missed for phosphate and potassium fertilizers that relied far less on Western technology.

Complex (NP and NPK) fertilizers that offer potential savings in transportation and application costs are in chronically short supply in the Soviet Union.[18] Installations purchased from Western firms in the 1960s and in partial operation in 1970 provided one-half or more of total Soviet output of such fertilizers that year and at least two-thirds of the total in 1973. By 1975, Western technology provided perhaps 40 percent of Soviet output of complex fertilizers because several Soviet-designed units were commissioned in 1973-75. Soviet plans for 1976-80 envision a substantial increase in production of complex fertilizers, including liquid types now made on a small scale using experimental equipment. Western equipment for seven liquid fertilizer plants ordered in 1976 should provide most of the Soviet liquid complex fertilizers based on polyphosphoric acid in 1980.[19] In addition Soviet purchases in the West in 1976 and through mid-1977 included eight installations for production of dry complex fertilizers. These will have a fertilizer nutrient production capacity totaling 2.7 million tons, almost equal to total Soviet production of complex fertilizers in 1975.

[16] Each of five Western-equipped installations commissioned in 1971-75 had annual production capacities of 450,000 tons. In addition, five lines believed to be based at least partly on Western equipment and/or technology were put into operation, each producing 200,000 tons a year.

[17] Western-equipped plants commissioned in 1971-75 accounted for 10 percent (about 5.1 million tons) of Soviet ammonia produced in 1971-75. In addition, an estimated 3.5 million tons came from Western installations purchased in the 1960s.

[18] Only 15 to 20 percent of Soviet fertilizer production in 1975 was accounted for by multinutrient types compared to more than one-half in the United States.

[19] In 1980, Soviet liquid complex fertilizers based on polyphosphoric acid are planned to include 700,000 tons of phosphate nutrient (P_2O_5). According to preliminary information, the Western-supplied plants may include capacity for producing this quantity. Part of this capacity, however, may not be in full operation by 1980.

Manmade Fibers [20]

Modern plants for producing chemical fibers are characterized by large-capacity, automated installations for both intermediates and end products and by the need for stringent quality control at all stages of production. Native Soviet developments in potentially large-volume fibers have generally been unexceptional or lacked an economic basis for commercialization. Slow development of process technology and equipment has been a major factor in this situation. The USSR relies heavily on Western manmade fiber technology and equipment, especially that used in producing acrylics and polyesters. A 50,000-ton-per-year polyester plant ordered from the United Kingdom in 1964 and three smaller facilities purchased earlier provided an estimated 60,000 tons (perhaps 75 to 80 percent) of Soviet output of polyester fibers in 1975. Facilities equipped with imported Western equipment may have provided two-thirds of the estimated 55,000-ton Soviet output of acrylic fiber in 1975.[21] Western equipment and technology also accounted in 1974 for almost one-half of Soviet production of caprolactam,[22] a nylon intermediate.

During the 10th Five-Year Plan the USSR again will be highly dependent on Western technology for fibers and fiber intermediates. Installations ordered during 1971-75 but not yet in operation at the end of 1975, together with a polyester fiber unit ordered in 1977, could provide new production capacity for about 162,000 tons of manmade fibers, equivalent to one-third of the planned 505,000-ton increase in Soviet production of these fibers in 1976-80. The capacities available from the imported Western equipment will include 97,000 tons of polyester fibers, 64,000 tons of cellulose acetate and triacetate, and 700 tons of spandex.

In addition, an estimated 20,000 tons or 85 percent of Soviet polypropylene fiber produced in 1980, will be made from polypropylene obtained from Western-supplied installations with a total production capacity of 130,000 tons. Most of the polypropylene probably will go to produce plastics. Other orders that will help meet Soviet requirements for nylon intermediates include a plant with an annual production of 80,000 tons of caprolactam and three installations with a combined production capacity of 96,000 tons of hydroxylamine. The Soviet Union has also made a preliminary agreement with a Western consortium for a huge polyester fiber complex during the 10th Five-Year Plan, including facilities for major intermediates. As yet no details are available on when the complex will be completed.

Plastics

Output of Soviet plastics has grown rapidly but invariably less rapidly than anticipated in five-year plans. Introduction of new production capacity in 1971-75 was only 45 percent of the original goal.[23] Production of plastics in 1975—2.84 million tons—was 700,000 tons short of the initial target.

Several plastics installations bought in the West in the 1960s had construction delays of one or two years but are now contributing substantially to Soviet production of certain major plastics. In 1975, Western-equipped plants are estimated to have supplied 240,000 tons of polyethylene and 120,000 tons of polyvinyl chloride, about three-fifths and one-third respectively of total Soviet output of these products. By the end of 1975 at least two of the polyethylene plants exceeded rated capacity as a result of reconstruction and modernization. Western sales to the Soviet Union also included installations for producing polyester film, Saran-type film, and intermediates for obtaining plastics. A 250,000-ton-per-year vinyl chloride plant purchased abroad and commissioned in 1975 doubled existing Soviet production capacity for that product. Soviet problems in operating such plants, however, are still continuing.

[20] Manmade or chemical fibers include cellulosics (rayon and rayon acetate) and the generally more modern, fast-growing noncellulosic (synthetic) fibers such as acrylics, polyesters, nylon, and polypropylene.

[21] Production of acrylic fiber by Western-supplied installations in 1975 may have amounted to about 35,000 tons based on estimated production of 25,000 tons at the largest facility, located at Polotsk.

[22] Total Soviet production of caprolactam in 1974 amounted to 247,000 tons. Capacities of Western-equipped plants in operation by the end of 1972 totaled 112,000 tons.

[23] The Ninth Five-Year Plan called for commissioning new capacity for producing 2.19 million tons of plastics; capacity actually introduced totaled only 981,000 tons.

Despite problems, Western plastics technology continues to be sought by the USSR and will make further large contributions to output. Soviet plans call for production of plastics to increase by 2.9 million tons during 1976-80 to 5.7 million tons. Western equipment ordered or delivered but not yet in operation by the end of 1975 could provide 1.2 million tons of production capacity for plastics by the end of 1980, as noted below:

Polyethylene	560,000 tons
Polyvinyl chloride	250,000 tons
Polystyrene	300,000 tons
Polypropylene	110,000 tons
Polyester film	5,000 tons

Even if these ambitious targets are met, no more than two-thirds of overall requirements for plastics will be met in 1980, including one-half or less of those for polyethylene and polypropylene. Soviet production of plastic pipe—11,000 tons in 1973—was only 1 percent that of the United States and met 10 percent or less of Soviet requirements. In 1976 Moscow ordered a plant from a West German firm capable of producing 50,000 tons per year of plastic pipe, but total output of such pipe clearly will not meet requirements for many years.

One possible bright light in the Soviet plastics picture is a high-pressure polyethylene plant developed by Soviet and East German researchers. The Soviet press claims that only five years were required to go from the project draft to commercial output in a 50,000-ton-per-year plant commissioned at Polotsk, Belorussia, in 1974. Additional plants of this type, some with larger production capacities, are to be built during the present five-year plan in the Soviet Union, East Germany, Poland, and Romania. The polyethylene plant is claimed to be highly automated and on par with the best installations of its type in the world.[24] Production from the plant allegedly will be able to compete on world markets. If the claims are valid and if capacities of future models can be successfully enlarged within a reasonable period, Communist dependence on Western high-pressure polyethylene technology will be substantially reduced. Soviet confidence in the unit will be signaled if officials select a similar unit—rather than a Western-equipped unit—for a large (150,000 tons per year) high-pressure polyethylene complex to be built at Tomsk in western Siberia. In any case, the Soviet – East German process may become obsolete before long. In the United States, Japan, and West Germany, new processes have been developed that reportedly permit low-pressure production of types of polyethylene formerly obtained only at high pressures. The new methods offer large savings in energy and capital costs compared to costs of high-pressure processes.

[24] Such claims are difficult to evaluate because Soviet technological claims in the past have not always proved valid. Even if the plant is as claimed, it is not easy to determine whether all the embodied technology was developed in the Communist countries.

Other Advantages of Purchased Western Technology

Imported Western equipment and technology apparently made fairly substantial contributions to productivity increases and cost reductions in the Soviet chemical industry in 1971-75, although information on the purchased facilities seldom permits comparison with aggregate Soviet data. During the five-year period, the average annual rate of growth of the chemical industry[25] exceeded that of all industry by about 43 percent.[26] Labor productivity in the chemical industry in the same period rose by 35.6 percent (CIA estimate), well above the 24.2-percent gain estimated for all industry. Chemical unit production costs reportedly fell by 8.3 percent and a reduction of more than 5 percent in overall chemical prices was claimed.[27]

Cost savings from imported Western chemical equipment include those resulting from shorter construction periods, highly productive equipment or processes, and reduced or less costly inputs of raw materials, energy, and labor. The

[25] Including the petrochemical sector, which is responsible for production of rubber and rubber products and many synthetic organic chemicals.

[26] According to CIA estimates, average annual production of Soviet chemicals grew by 8.6 percent in 1971-75 compared to 6 percent for all industry.

[27] The reduction in production costs and prices may apply only to the Ministry of the Chemical Industry (that is, excluding the petrochemical sector).

period between Soviet orders and initial operation of Western-supplied plants that were commissioned in 1971-75 generally was three to five years. The average duration of construction for all Soviet chemical plants is eight years.[28]

Western process technology has facilitated Soviet use of more economical feedstocks and processes. Savings of 50 percent in Soviet production costs for melamine, a product used in dinnerware, surface coatings, and adhesives, were anticipated as the result of the commissioning in 1972 of an imported facility based on a petrochemical derivative, urea, rather than calcium cyanamide.

A one-stage process for production of butadiene, a major intermediate used in producing rubber, was commissioned in 1975 at Nizhnekamsk, Tatar ASSR. The Nizhnekamsk installation was the first commercial-scale facility in the USSR to employ the one-stage process. According to a Soviet text on petrochemicals, published in 1973, this process requires at least 20 percent less butane per ton of butadiene than a two-step process.

Average production costs for ammonia in the chemical industry reportedly fell by 8.5 percent during 1971-75 as a result of introduction of large ammonia plants based on Western technology.[29] Soviet publications suggest that unit production costs and capital investment at individual plants using Western ammonia technology are 30 to 50 percent below costs of older Soviet plants. Such ammonia plants, the first of which was commissioned in 1973, may provide economies in capital investments totaling roughly 800 milion rubles for installations commissioned through 1980.[30] Annual savings in operating costs by these plants when they approach rated capacity could range from 200 million to 465 million rubles.[31] If the Soviet production goal for ammonia in 1980—23.1 million tons—is met, the estimated savings could be 9 to 20 percent of the value of ammonia production.[32]

Sharply reduced energy and manpower requirements contribute to the economies provided by the imported ammonia plants. The Western technology permits a more than 95-percent reduction in electric power consumption per ton of ammonia compared with technology used in earlier Soviet-designed units. At a large Western-equipped installation in Novomoskovsk, the electric power input per ton of ammonia is 56 kilowatt hours (kWh), while older units at the same plant consumed 1,291 kWh per ton. Electric power savings of 2.3 billion kWh may have resulted in 1975 just from operation of five 450,000-ton-per-year installations that were based on Western technology [33] and is equivalent to an annual saving of about 780,000 tons of standard fuel. By 1980, total Soviet economies in the use of electric power for production of ammonia will be much greater, in view of the plans for commissioning 26 additional installations of the same size. Savings in electric power are particularly important in the chemical industry, which

[28] A Western-equipped ammonia plant at Novgorod that was commissioned in 1975 took a little less than three years to build; earlier construction of a Soviet ammonia unit at the same plant required eight years, although its production capacity was less than one-half that of the imported installation.

[29] The reported reduction may only apply to the Ministry of the Chemical Industry, but its plants produce the bulk of the ammonia made in the Soviet Union.

[30] Equivalent to 20 percent of investments in the chemical industry in 1976. The USSR ordered 39 complete or partial ammonia plants from Western firms in 1969 through mid-1977, but a number of these probably will not be in operation by 1980. Soviet plans call for commissioning 26 large ammonia plants in 1976-80 in addition to the five completed in 1973-75. According to a 1973 Soviet publication, plants producing 400,000 to 450,000 tons of ammonia a year were each expected to reduce capital investment by 25 million rubles, presumably as compared with investment costs for older Soviet-designed plants that would provide comparable production capacity. The Soviets claim to have developed their own version of the large (1,360 tons per day) ammonia installations but it is believed that at least some features of Western technology or equipment have been incorporated.

[31] A 1973 Soviet publication indicated that ammonia plants with annual production capacities of 400,000 to 450,000 tons would each permit reductions of 15 million rubles in annual operating costs. Assuming 31 such plants will have been commissioned in 1973-80, potential annual savings would be 465 million rubles. A second Soviet source, however, predicted that such plants erected through 1980 would provide annual savings of 200 million rubles. The latter source may have been based mainly on a comparison of Western-designed plants to an improved but still inferior Soviet version.

[32] The estimated value of ammonia output in 1980 is based on the Soviet production goal plus the wholesale price (97 rubles per ton as of 1 July 1977) that Soviet producers receive for ammonia.

[33] The estimate assumes 85-percent utilization of capacity and a saving of 1,200 kWh per ton of ammonia. Actual savings could vary somewhat, depending on the vintage of the installation replaced or the efficiency of the ones that would have been built if Western technology were not available.

produces less than 7 percent of Soviet industrial output but uses 11 to 12 percent of the electric power consumed by industry.

According to Soviet publications, the technically advanced ammonia plants require between 10 to 30 percent as many workers per ton of ammonia as do the older Soviet plants. The first 450,000-ton-per-year unit based on Western technology (at Nevinnomyssk) employed 82 workers, whereas 500 workers were needed at an ammonia plant at Dzerzhinsk that had less than half the productive capacity. The seven plants producing liquid complex fertilizer ordered in 1976 could yield substantial economies in labor inputs compared with the production and use of dry fertilizer mixtures. Soviet calculations based on an experimental domestic unit indicate a possible saving of 300,000 man-hours per 100,000 tons of phosphate nutrient (P_2O_5). If we assume at least equivalent savings from the purchased plants, which will be based on the same raw materials as the experimental Soviet unit, annual economies in labor inputs could amount to 2.1 million man-hours. Potential advantages of selected Western chemical technologies purchased by the USSR in recent years are shown in table 3, together with evidence of worldwide acceptance of certain of the processes. The benefits stipulated are largely those claimed by the licensors, but the information suggests that the Soviets have been purchasing technology that ranks high internationally.

Advantages of technology transfer are enhanced when manufacturers in the recipient country can duplicate the imported equipment at a reasonable cost. Evidence suggests that the Soviets have not been able to copy Western chemical equipment on a substantial scale. They probably can produce spare parts for some plants, however, and apparently were successful in negotiating for the right to reuse Western designs for some parts of large ammonia plants. Few details are available on such arrangements, and even less is known of possible Soviet efforts to duplicate imported chemical equipment without permission. It is possible, however, that 300,000-ton-per-year Soviet ethylene plants now under construction will incorporate some features of a larger ethylene unit imported from the West. The 300,000-ton-unit and the larger one purchased earlier potentially offer substantial advantages over the 60,000-ton units[34] that are used in several Soviet plants. Table 4, published in 1974 in a Soviet journal, contains data on the three ethylene variants.

Because of continuing problems experienced in building and operating new plants, the USSR is unlikely to achieve the full benefits of larger chemical installations. Economies of scale should nevertheless be sizable. Moreover, because of recent trends in new technological developments, chemical installations and technology purchased from Western firms in the last five or six years probably will not obsolesce relative to their Western counterparts as rapidly as the facilities commissioned in the USSR in the 1960s and early 1970s. Soviet inefficiency in construction and operation of chemical plants then was occurring at a period of rapid Western technological advances and of construction of ever larger complexes that promised economies of scale. More recently, the advantages of size and technology have become relatively less important to Western chemical firms faced with escalating feedstock and construction costs.

Western technology will have an important role in implementing Soviet plans to reduce chemical production costs by 9 percent during the 10th Five-Year Plan.[35] Part of the economies are to come from a 9-percent reduction in unit inputs of materials and energy. This will require, among other measures, the use of more effective catalysts and greater reliance on automated control systems. The USSR will use catalysts developed in the West in large imported installations for producing acrylonitrile, acetic acid, and a number of other chemicals. As for process

[34] The most recent Soviet-manufactured ethylene plant, which was put into operation at Kazan in 1975, can produce 100,000 tons a year. Two ethylene installations are planned for operation in the USSR in 1978. Each will have a production capacity of 300 000 tons a year and will incorporate pyrolysis and compression equipment made in Czechoslovakia. The Western-supplied ethylene unit, commissioned at Nizhnekamsk in 1976, has a rated annual production capacity of 450,000 tons.

[35] Nevertheless, the Soviet plans to reduce chemical production costs probably will not be fully implemented; the chemical industry exceeded the scheduled level of production costs in 1976 and 1977.

Table 3

USSR: Features of Selected Chemical Technology Purchased in the West, 1970-77 [1]

Product	Typical Product Uses	Country of Licensor and Year of Contract	Process and/or Raw Materials	Features [2]
Acetic acid	Acetates for textiles, computer tapes	United States 1973	Low-pressure process using methanol and carbon dioxide.	Low-pressure process considered significantly better than earlier processes. Uses highly selective catalyst system and provides high yields. As of January 1976, license granted to six companies worldwide with manufacturing capacity of almost 1.3 million metric tons. Process termed "best in world" by Soviet trade official.
Acrylonitrile	Acrylic fibers, nitrile rubber, acrylonitrile-styrene copolymers, grain fumigant	Italy 1974	Steam dilution of propylene-ammonia-air feed in presence of a catalyst.[3]	Special catalyst reduces raw material inputs and increases yields. Catalyst also lessens likelihood of pollution by reducing waste water contaminants. Process had been licensed to 34 manufacturers worldwide as of August 1975.
Ammonia	Fertilizers, explosives, refrigerants, nylon, nitric acid, and acrylonitrile	United States 1969-71 1973-76	Catalytic reaction of nitrogen from air with hydrogen obtained from high-pressure reforming of hydrocarbons (usual source is natural gas).	Plants characterized by large single-train installations that employ centrifugal compressors, an integrated energy system, and improved catalysts. Process permits sharp reductions in investment and production costs compared to earlier processes. Unit inputs of electric power, water and manpower substantially reduced. Half of world's ammonia in 1977 may have been produced in plants using this technology.
Bisphenol A	Polycarbonate, epoxy and polysulfone resins	France 1976	Reaction of phenol and acetone in the presence of a catalyst.	Installation ordered by USSR (75,000 metric tons per year) one of the largest such plants in the world.
Butadiene	Synthetic rubber, nylon fibers and resins	United States 1970	One-stage dehydrogenation of butane (Catadiene process).	Uses large-capacity reactors, turbocompressors and automated control system. Installation purchased by USSR reportedly was largest "Catadiene" plant in the world, with annual production capacity of 90,000 tons of butadiene. Soviets claim the one-stage process permits a 40-percent reduction in unit investment and production costs [4] and at least doubles labor productivity compared to the existing two-stage process.

Table 3 (Continued)

USSR: Features of Selected Chemical Technology Purchased in the West, 1970-77 [1] (Continued)

Product	Typical Product Uses	Licensor and Year of Contract	Process and/or Raw Materials	Features
Caprolactam	Synthetic fibers, plastics, film, synthetic leather, plasticizers	Italy 1975	Based on toluene.	Avoids formation of ammonium sulfate, often an undesirable byproduct. Pollutants are eliminated from waste water.
Paraxylene	Polyester fibers, films, and resins	United States 1976 (two identical complexes ordered)	Separation of paraxylene from mixed xylene feedstocks by continuous, selective adsorption. Uses fixed bed of solid adsorbent.	Claims include increased yields, reduced investment and production costs. Process minimizes corrosion.
Phthalic anhydride	Plasticizers, alkyd resins, polyester resins	West Germany 1976 [5]	Phthalic anhydride produced from orthoxylene by continuous distillation.	Used in nearly 50 plants worldwide. High degree of automation. Higher yields than processes using naphthalene as raw material (as of late 1974 more than 80 percent of Soviet phthalic anhydride was based on naphthalene). Facilities provided to the USSR will include pollution control equipment.
Polyester fiber	Tire fabric, clothing, reinforcement of rubber hose for seawater cooling systems	West Germany 1973	Raw materials are dimethyl terephthalate and ethylene glycol.	As of late 1975, plants using process had a total annual production capacity of 400,000 tons. Plant ordered by USSR was largest single-train plant of its kind (50,000 tons of polyester fibers and 18,000 tons of polyester chips).
Polyethylene (high-density)	Pipe, film, wire and cable, food and beverage containers, shipping drums	United States 1974 1977	Gas-phase process for manufacture of high-density polyethylene (HDPE) from ethylene. Fluidized bed reactor is used.	Licensor claims savings of 25 percent in capital investment and 15 percent in operating costs, compared to the most efficient competing processes (November 1975). No solvents or dispersants are required as reactant carriers, thus reducing pollutants.

[1] This table is intended only as a rough guide to the types and characteristics of Western chemical technology ordered by the Soviet Union in recent years.

[2] Includes advantages or potential benefits (usually those claimed by licensor), unique features, or evidence of worldwide acceptance.

[3] Process, including a special catalyst, was developed by a US firm; the Italian firm has license from the US firm permitting the sale to the USSR.

[4] An alternate Western process that recovers butadiene as a coproduct of ethylene in steam crackers may be more economical than the one-stage process described. Choice, however, depends on the feedstocks available. Heavy feeds used at steam crackers can provide cheaper butadiene, but lighter feeds minimize production costs of ethylene.

[5] In early 1977, the USSR ordered a second phthalic anhydride plant of the same capacity (60,000 metric tons per year). Combined capacity of the two plants is equivalent to total Soviet production of this product in 1974.

Table 4

USSR: Technical-Economic Indexes for Production of Ethylene in Installations of Various Capacities [1]

	EP-60	EP-300 [2]	EP-450
Number of installations	5	1	1
Annual production capacity (Thousand metric tons)	300	300	450
Capital investment per ton of ethylene (Index: EP-60 = 100 percent)	100	50.7	37.0
Production cost per ton of ethylene (Index: EP-60 = 100 percent)	100	49.5	40.0
Conditional annual economic effect relative to an EP-60 plant (million rubles)	—	>10	>13

[1] The letters EP are used in the Soviet Union to designate installations that produce ethylene and propylene. The numbers following EP represent the annual ethylene production capacity in thousand metric tons. Data on EP-450 may have been based on anticipated costs of a Western-equipped installation commissioned in 1976.

[2] Data on EP-300 presumably represent Soviet estimates. No installations of this type were in operation as of mid-1977.

control equipment, Western-designed chemical plants are almost always more highly automated than those designed in the Soviet Union.[36] The purchased installations should therefore permit reduced consumption of materials per unit of output and increased product yields. These benefits, however, will not be automatic. Soviet technicians lack experience with the complex control systems that characterize many Western chemical facilities.

Economies in unit investment and production costs will help offset increased expenditures on pollution control and larger capital outlays in areas east of the Urals, where construction costs are at least 20 percent higher than in European USSR. About 1 billion rubles are to be spent on pollution control in the chemical industry during 1976-80, 25 percent more than was planned for 1971-75. Chemical investment in facilities east of the Urals is to account for 24.2 percent of total chemical investment during the present plan period compared with 21.7 percent of a much smaller total investment during 1971-75.

[36] In 1971-75 automation and mechanization accounted for only about 5 percent of total expenditures for equipment in the Soviet manmade fiber industry. In the United States and Japan, such expenditures can reach 25 percent of total outlays for equipment.

Quality Considerations

The continued low quality of many Soviet chemical products[37] suggests that gains from imported Western technology have been well below what might have been expected. Nevertheless, in at least a few major product sectors (manmade fibers, plastics), some of the plants that have received substantial quantities of Western equipment rank well above the average in product quality. In any case, the need for higher quality products apparently is a factor in Soviet decisions to buy at least certain chemical installations.

Information on the generally low quality of Soviet chemicals is based largely on Soviet articles about the so-called Seal of Quality approved by the Soviet Committee of Standards, Measures and Measuring Instruments in 1967 and awarded to the highest quality products of all types by authorized commissions for periods of one to three years. In some cases, the award is a prelude to approval of a higher price and the granting of bonuses to workers. Comparability of high-quality Soviet chemical products with similar Western products is uncertain. To be sure, the need for products with certain specifications depends mainly on the intended end use, and applications exist for which lower quality products are acceptable. Nevertheless, many Soviet chemicals (for example, dyes)[38] probably would be considered unacceptable in the United States.

The Seal of Quality had been awarded for 6.5 percent of the output of the Ministry of the Chemical Industry as of November 1973. In

[37] In 1969, only 22 to 25 percent of the products of the Soviet Ministry of the Chemical Industry reportedly were on the level of the best world standards. Although some improvement has occurred, articles in the Soviet press confirm continuing quality shortcomings for many products, including manmade fibers, dyes, plastics and other goods. The criticism also extends to industrial rubber goods, production of which is in the purview of the Ministry of Oil-Refining and Petrochemical Industry.

[38] The Soviet Union has three quality categories: superior, first category, and second category. Production of items in the second category is supposed to be stopped unless quality is sharply upgraded. Implementation of the regulation can be avoided, however. For example, as of 1974, only 1 percent of Soviet dyes were assigned to the second category, despite complaints in Soviet publications that suggest a higher proportion of substandard dyes.

1975 the share rose to 11 percent,[39] but the performance clearly was still unsatisfactory. That year the Ministry received 3,000 complaints concerning poor quality chemicals. Products valued at 5 million rubles were not sold because of poor quality. These figures probably do not reflect the true volume of substandard products. Industries that use chemicals cannot afford to reject too large a quantity because of the adverse effect on their own production programs. Agricultural consumers of fertilizer also can ill afford to return poor-quality products, yet only 2 percent of Soviet fertilizer output in 1976 had earned the Seal of Quality.

In the manmade fiber industry, which bought about $750 million in Western equipment in 1957-73, only 6.5 percent of output in 1975 bore the Seal of Quality. The poor quality of some products made in Western-equipped plants often results from the marriage of an imported basic materials plant to a Soviet-designed raw material facility, from the use of unsatisfactory additives or processing agents, or from the failure to keep working areas free of dust and dirt. At a largely Western-equipped polyester plant at Mogilev, the Seal of Quality was denied to the plant's colored fibers because poor-quality dyes were used. Nevertheless, in 1975 the Mogilev facility apparently ranked first among Soviet synthetic (that is, noncellulosic) fiber plants in the share of output that had been awarded the seal.[40] The second-ranking plant, located at Chernigov, has two or three Western-supplied nylon installations. Almost one-fourth of the output of a polymers complex at Polotsk[41] had the Seal of Quality in 1975, compared to an average of 8.5 percent for enterprises of the All-Union Plastics Association to which it belongs. At a plant at Kazan, where more than 40 percent of the polyethylene produced in 1975 had the Seal of Quality, all the polyethylene-producing equipment appears to be of Western origin.

The poor quality of domestic chloroprene rubber[42] apparently was an important factor in the Soviet decision to order Western equipment for a chloroprene monomer unit in 1973[43] and a chloroprene polymer unit in 1976. The average quality of Soviet chemical products obviously will continue to benefit from Western technology in view of the large volume of chemical equipment ordered in the West in the last three or four years. Plans for the Ministry of the Chemical Industry call for output bearing the Seal of Quality to almost double during the 10th Five-Year Plan, reaching 20 percent of the total output of the Ministry in 1980.

Impact of Equipment Purchases on Soviet Foreign Trade in Chemicals

Despite its extensive purchases of Western chemical equipment and technology, the USSR remains a net importer of chemicals. In 1975 total Soviet chemical imports exceeded exports by about $925 million,[44] almost triple the deficit in 1970. Actually, output from the Western-

[39] Certain chemical-producing sectors of the Ministry of Petroleum Refining and Petrochemical Industry have a higher share of output bearing the Seal of Quality than do most sectors of the Chemical Ministry. By the end of 1975, products bearing the seal accounted for 34 percent of the output of the synthetic rubber sector, 36 percent of the output of the tire industry, and more than 70 percent of the output of the carbon black sector.

[40] In 1975, 19.4 percent of the output of the Mogilev Chemical Fiber Association had the Seal of Quality compared to the average—8.3 percent—for enterprises of the synthetic fiber sector. Although the Mogilev Association, which was formed during 1975, also has a rayon (that is, cellulosic) plant, the 19.4 percent apparently refers mainly, if not exclusively to the Western-equipped synthetic fiber complex. Less than 1 percent of the rayon plant's output had the Seal of Quality as of 1975.

[41] The polymers facility has a number of Western-supplied installations, including several polyethylene units, an ethylene plant, and an acrylonitrile plant. A Soviet – East German polyethylene plant is also part of the complex.

[42] An oil-resistant type of rubber with many uses in industrial rubber goods.

[43] The order for the chloroprene monomer plant came only a month after an article in the Soviet press indicated that the Armenian plant produced the poorest rubber in the Soviet Union.

[44] In 1975 Soviet chemical imports and exports accounted for 5.8 percent and 3.6 percent, respectively of total Soviet imports and exports. For purposes of this report, the list of items identified as chemicals in Soviet trade statistics was partially adjusted to more closely approximate coverage in category 5 of the Standard International Trade Classification (SITC). To better reflect the range of products produced in Western-equipped plants, however, chemical trade is defined as also including trade in synthetic rubber and rubber products, manmade fibers, and photographic materials.

supplied facilities has been somewhat more important than the trade data would suggest and will become much more significant by the early 1980s, in part because of product buy-back agreements associated with chemical equipment purchases.

Changes in the volume or structure of Soviet chemical trade in the 1970s that stemmed at least in part from earlier Soviet purchases of Western equipment included exports of urea fertilizer and caprolactam, an intermediate used in producing nylon. Soviet exports of urea fertilizer in 1975 were valued at more than $135 million compared to $2.5 million in 1965.[45] The USSR shifted from being an importer of caprolactam in the 1960s to an exporter in the 1970s after commissioning two large Western-equipped plants. Such examples, however, are relatively few. Because the Soviet Union has large and growing requirements for many chemical products, an increase in domestic output will not necessarily result in an immediate reduction in imports or an increase in exports. Without the imported equipment, however, the USSR would either have had to import a larger volume of chemicals or aggravate the already serious shortages that existed for many products such as plastics and manmade fibers. Similarly, without the imported fertilizer installations, larger Soviet imports of agricultural products might have occurred.

By the early 1980s the pattern and volume of Soviet chemical trade will change substantially. Moscow hopes to expand chemical exports by as much as 150 percent during 1976-80, according to the head of a major Soviet chemical trade organization. The enhanced Soviet production capabilities resulting from purchases of Western equipment will permit larger Soviet exports of methanol and plastics, as well as some deliveries of complex fertilizers to Eastern Europe.

Buy-back agreements will provide a major stimulus to Soviet chemical exports to the West in this period. Of the more than 60 compensation agreements with Western firms signed by the USSR through mid-1977, half involved chemical equipment purchases. Annual Soviet chemical sales in the West resulting from the buy-back agreements will exceed $300 million[46] by the early 1980s. The sales will, however, depend on the Soviets meeting at least minimum quality standards specified for such products in the West.

Prominent among rising Soviet exports to the West will be ammonia, methanol, polyethylene, polystyrene, and other chemical products. Soviet sales of ammonia resulting from the buy-back agreements plus a separate fertilizer exchange arrangement with Occidental Petroleum Corporation could average 3.15 million tons annually in 1978-87 if agreements are implemented. It seems unlikely, however, that this quantity can be absorbed by world markets, particularly since world exports of ammonia have averaged only slightly more than 3 million tons in recent years. Even with some slippage probable in Soviet construction of new ammonia plants, intense competition is in prospect for world ammonia markets in 1980-81, if not earlier. Producers in the developed Western countries almost certainly will be affected, and with depressed prices and profits in store, the closing of at least older ammonia plants in those countries is likely.

Soviet production capacity for methanol will double as a result of a 1977 order for two huge plants that will have a combined capacity roughly equivalent to 15 percent of world methanol capacity in 1977. Western firms are to purchase at lease 300,000 tons per year of Soviet methanol in connection with this order. The impact on Western markets will largely depend on how rapidly new uses develop for methanol as

[45] The enhanced capability to export urea probably reflects Soviet equipment purchases from Eastern Europe as well as from the West. Equipment from both sources accounted for 64 percent of total Soviet production of urea in 1973.

[46] The estimate is largely based on the value of those Soviet orders of chemical equipment from 1972 through mid-1977 that are associated with compensation agreements. The product buy-back, which in some cases also will offset interest charges, generally will begin in 1978-81 and continue for eight to 10 years. The $300 million per year does not include any direct Soviet sales of chemicals on world markets. Nor does it include the value of sales that will result from a Soviet fertilizer exchange agreement with Occidental Petroleum Corporation. Soviet sales under the latter agreement could add more than $300 million annually to its hard currency earnings but these will be fully offset by Soviet purchases of superphosphoric acid.

a fuel or fuel additive or as feedstock for artificial protein or petrochemicals. In 1976 the USSR, with foreign sales of more than 215,000 tons, was the world's fourth largest exporter of methanol.

Obstacles to Soviet Realization of the Full Potential of Western Technology

As noted earlier, Western equipment and technology contributed substantially to increased production of nitrogen fertilizers and certain plastics and synthetic fibers. Contributions to improved product quality and to overall efficiency of the Soviet chemical industry have been more modest, mainly because of chronic problems in the construction and operation of new plants. These difficulties often stem from Soviet inexperience in the installation, operation, and maintenance of complex chemical equipment and from poor planning and management, and partially offset the potential gains from the imported plants. Pressure appears to be mounting for institutional changes that will ensure better management of large chemical construction projects that incorporate Western technology. As yet, such changes appear to be few and ineffective, as illustrated by the following examples from recent Soviet press articles. At the site of a major petrochemical project in West Siberia beset by delays and disorder, the secretary of the local party committee was unaware that a director for the project existed. This function, however, had been entrusted to the State Planning Committee (Gosplan), which was supposed to ensure at least unified financial planning. Gosplan had not met its responsibilities, however, thus contributing to the lack of coordination among the various ministries entrusted with the project. At a second large petrochemical project the most urgent task was said to be the creation of a management organ with the necessary rights to coordinate efforts of all participants in construction.

The problems affecting construction and assimilation of new chemical plants are so severe that they probably will continue to prevent full Soviet realization of the benefits of technology transfer. During 1971-75 the value of unfinished construction of chemical projects rose by 75 percent,[47] well above the 49-percent increase registered for all Soviet production-associated projects and the 42-percent increase in chemical investment. Implementation of Soviet plans to reduce average construction periods for chemical projects by 13 percent during the 10th Five-Year Plan appears far from assured.

Even if the planned reduction is achieved, delays in building many Western-supplied projects will continue. A large facility for obtaining intermediates used in production of polyurethane foam was scheduled for operation in late 1975 but was not yet producing in 1977. An ammonia pipeline being built between Grigoryevka and Tolyatti is behind schedule and is unlikely to meet its 1978 deadline. Construction delays at Soviet-designed facilities that are to service imported plants may also affect operation of new installations. At the site of a proposed reserve electric power substation that will service a massive Western-equipped ammonia complex under construction at Tolyatti, only "gophers, not excavators" were digging as of November 1976, although the substation was scheduled for operation in 1977.

Poor workmanship and carelessness frequently cause delays during the precommissioning stage of chemical projects. Shortcomings include poor-quality welding by Soviet workers, errors in the installation of equipment and insulation, and improper operation and servicing of machines and instruments. The persistence of such construction and preoperational problems indicates that the Soviets could have trouble meeting at least initial chemical export commitments under compensation agreements.

On the operational side, other factors hinder effective Soviet use of new chemical technology. For example, supply relationships between different ministries can frustrate efforts to use local raw materials and thus inflate costs. A large Western-supplied glycerine plant commissioned at Sterlitamak in 1972 was scheduled to receive propylene by pipeline from a nearby facility at Salavat. As of late 1975, half of the propylene

[47] Because of the large volume of Soviet chemical equipment purchases, the data partially reflect delays in construction of Western-equipped plants.

required had to be obtained by tank car from suppliers "thousands of kilometers away" because the local supplier gave preference to customers in its own ministry. The capability of domestic producers to supply high-quality spare parts and raw and other materials also will affect the value of technology transfer. In the case of an acetate fiber plant, the Soviets are concerned about the availability of domestic cellulose of the proper specifications, of filters and of lubricants after the six-month supply left by the Western contractor is exhausted. Efficient Soviet repair of expensive, often complex imported facilities also will be a problem. Plans to set up repair organizations to service large, automated ammonia plants have already been criticized in the Soviet press because the organizations, as presently conceived, would be too small and insufficiently specialized and mechanized.

How effectively chemicals are distributed and used in the Soviet Union will provide a final test of the utility of technology transfer. Drastic improvements are needed, for example, in the transportation, storage, and application of fertilizers. Inefficiency in these areas currently causes losses of 10 percent or more of the fertilizer allocated to Soviet agriculture. Despite all these problems that reduce the effectiveness of chemical technology transfer, it should be noted that the Soviet regime finds the alternative unacceptable at present. Given the difficulties that have been experienced in commercializing domestic technology, this judgment appears sound.

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APPENDIX

USSR: Contracts For Purchase Of Chemical Equipment And Technology From Non-Communist Countries, 1971-75

Year of Contract	Type of Plant or Equipment	Production Capacity (Thousand metric tons per year) [1]	Exporter: Country	Exporter: Firm [2]	Plant Sites and Comments	Scheduled Completion Date
AGRICULTURAL CHEMICALS AND RELATED FACILITIES						
1975	Ammonia (four plants)[3]	1,800 total	Japan	Mitsui and Company Toyo Engineering Corporation	Cherepovets, Novgorod, Dneprodzerzhinsk and Dorogobuzh	1979
			United States	Pullman Kellogg	Pullman Kellogg will supply technology.	
1975	Ammonia pipeline [3] (Tolyatti to Odessa)	—	France	Entrepose S.A. Vallourec S.A. (to supply pipe) Sofregaz (consultant)	Involves French credit of about $230 million. Compensation deal. Occidental to make counterpurchases of ammonia. The 2,400-kilometer pipeline, which has the capacity of 2.5 million tons of ammonia per year includes a 300-kilometer branch line to Gorlovka.	1978
			United States	Occidential Petroleum Williams Bros. (design consultant) Mapco Inc. (consultants)		
1975	Urea (two plants) [3]	1,000 total	Italy	ENI Snamprogetti (an ENI subsidiary)	Both plants to be at Tolyatti. Buy-back agreement also covers a Soviet order for a urea plant in 1974. Italian firm, Anic, to purchase 100,000 tons of Soviet ammonia annually over a 10-year period starting in 1979. Agreement may also call for Italian purchase of urea.	1977
1974	Ammonia (four plants) [3]	1,800 total	United States	Chemico	Tolyatti. Chemico will design and engineer plants and obtain materials and equipment. All equipment is to be purchased in the United States. Financing by US Export-Import Bank and US private banks. Compensation deal involving purchase of 600,000 tons/yr. of Soviet ammonia for 10-year period by Occidental Petroleum Corp. The 600,000 tons/yr. may also cover ammonia to be purchased in connection with Soviet order of fertilizer handling equipment at two Soviet ports.	1978

1974	Ammonia (four plants)[3]	1,800 total	France UK Japan UK	Creusot-Loire Kellogg International Mitsubishi Doulton Industrial Products	Two plants at Gorlovka and two at Odessa. Repayment in part by shipment of 300,000 tons/year of ammonia to France beginning 1978. Mitsubishi will supply four turbine compressors for $3.54 million of the contract value, and Doulton will supply filtration equipment for $178,800.	End of 1977
1974	Installation for storage, cooling and transport of ammonia	60 (storage)	France	Constructions Metalliques de Provence (CMP)	Tolyatti. Storage and loading equipment will serve rail tank cars and pipeline facilities.	1977
1974	Compressors	NA	United States	Dresser Industries	Most of the compressors will be used in production of ammonia.	NA
1974	Two fertilizer-handling facilities[3]	—	United States	Occidential Petroleum	Odessa area and Ventspils. Contract covers design and construction of handling facilities at the two ports. Product buy-back (ammonia) by Occidental is apparently involved	1977
1974	Urea handling equipment	—	West Germany	Pohlig-Heckel-Bleichert Vereinigte Maschinenfabriken AG	Odessa. Equipment for storage and loading urea.	NA
1974	Ammonia storage equipment	—	France	Constructions Metalliques de Provence	Gorlovka	NA
1974	Urea plant[3]	500	Italy	Tecnimont Montedison	Gorlovka Compensation arrangement involves purchase of Soviet ammonia by Montedison over a 10-year period starting in 1978.[4]	1978
1974	Urea plant[3]	500	Italy	Snamprogetti ENI	Novomoskovsk. Contract covers design, engineering, procurement, and assistance with startup. Buy-back involves Italian counterpurchase of Soviet ammonia and possibly urea. See comment on 1975 Soviet order for two urea plants.	1978

Footnotes at end of table.

USSR: Contracts For Purchase Of Chemical Equipment And Technology From Non-Communist Countries, 1971-75 *(Continued)*

Year of Contract	Type of Plant or Equipment	Production Capacity (Thousand metric tons per year) [1]	Exporter		Plant Sites and Comments	Scheduled Completion Date
			Country	Firm [2]		
AGRICULTURAL CHEMICALS AND RELATED FACILITIES (Continued)						
1974	Electric vibrating screens for fertilizer production	—	UK	Clark Chapman, Ltd.	NA	NA
1974	Cotton herbicide plant	NA	West Germany	Lurgi	NA	NA
			Switzerland	Ciba-Geigy		
1973	Ammonia plant equipment: pipes, valves, motors, instruments and electric machinery	NA	Japan	Toyo Engineering Corporation	Equipment may be for three plants each with a capacity of 450,000 tons/years.	NA
	Four compressors	NA	United States	Clark Company		
1971	Ammonia (four plants)	1,800 total	Japan	Toyo Engineering Corporation	Contract covers only main machinery and equipment. Plant designs may be similar to some provided earlier by a US firm.	NA
CHEMICAL FIBERS AND INTERMEDIATES						
1975	Caprolactam unit [3]	80	Italy	Snia Viscosa	Chirchik. Compensation deal involving counterpurchase of caprolactam by Snia Viscosa.	NA
1975	Polyester staple fiber equipment	12	UK	Constructors John Brown, Ltd.	Mogilev. Expansion. Contract involves UK credit.	1978
				ICI Fibers Division (Process Technology)		
1975	Polypropylene unit [3]	100	Italy	Tecnimont	Tomsk. Compensation deal. Product will be used to produce fibers, film and plastics.	1979
1975	Nylon filament spinning plant	0.7	Japan	C. Itoh	Chernigov. Payment in cash.	NA
				Toyobo Spinning Co.		
1974	Acrylonitrile plant [3]	22	Japan	Asahi Chemical Industry Company	Polotsk. 25-percent downpayment; balance in deferred payment over seven-year period at 6.5 percent.	NA

1974	Acrylonitrile plant [3]	150	Italy	Tecnimont	Saratov. Tecnimont will provide planning, machinery, and construction. Some US process technology will be used.	1978
1973	Polyester staple fiber	50	West Germany	Uhde Hoechst (technology)	Mogilev. Contract covers design, engineering and procurement of equipment.	1976 first of four lines went into operation mid-1977
1973	Dimethyl terephthalate plant	6	UK	Sim-Chem.	Mogilev. Contract covers design, engineering and supply of equipment. Expansion of existing installation.	mid-1975
1973	Cellulose triacetate plant	15	UK	Prinex Ltd. (a Courtauld subsidiary)	Engels. Financed through 10-year bank loan.	1976 (first stage accepted, July 1978)
1972	Hydroxylamine plant	16	West Germany	Badische Anilin, and Soda Fabrik AG	Shchekino. End-product to be used for production of caprolactam.	1974 (actual 1976)
1972	Hydroxylamine (two plants)	80 total	West Germany	Badische Anilin and Soda Fabrik AG	Grodno and Kemerovo. End-product to be used for production of caprolactam.	1975 (actual 1978)
1972	Carbon disulfide plant	60	Italy	SNIA Viscosa	Possibly to be built at Sokol.	1974
1972	Dimethyl terephthalate (DMT) plant	54	West Germany	Friedrich Krupp GmbH Chemische Werke Witten	Mogilev. The DMT will be used to produce polyester fiber.	1975 (actual start-up 1976)
1972	Acetate fiber tow plant	7	West Germany	Lurgi Mineralol Technik	Kirovakan. End-product to be used to produce filter tips for cigarettes.	End of 1975 (operational early 1977)
1972	Cellulose triacetate plant	42	Italy	Montedison	Fergana	1975 (revised to 1978)
1972	Polypropylene plant	30	Italy	Montedison	Guryev	1975 (actual 1977)

Footnotes at end of table.

USSR: Contracts For Purchase Of Chemical Equipment And Technology
From Non-Communist Countries, 1971-75 *(Continued)*

Year of Contract	Type of Plant or Equipment	Production Capacity (Thousand metric tons per year) [1]	Exporter: Country	Exporter: Firm [2]	Plant Sites and Comments	Scheduled Completion Date
CHEMICAL FIBERS AND INTERMEDIATES (Continued)						
1972	Nylon tire cord plant	3.7	West Germany	Zimmer AG	Chernigov	1974 (actual startup possibly 1975)
1971	Spandex fiber plant	0.7	Japan	C. Itoh Toyobo Hodogaya Chemical Toyo Gosei Kawasaki Heavy Industries	Volzhskiy	1974 (actual startup January 1976)
1971	Heat exchangers for manmade fiber	NA	UK	Coventry Radiator and Press Work Company, Ltd.	NA	NA
1971	Recovery unit for catalysts used in producing acrylonitrile	540 (tons/day)	Japan	Japan Gasoline Co. Catalysts and Chemicals Industries Co.	Possibly Polotsk	January 1973 (possibly commissioned in 1974)
PETROCHEMICALS AND RELATED EQUIPMENTS [5]						
1975	Detergents [3] (surface active agents)	15	Italy	Pressindustriya	Compensation deal. Pressindustriya will purchase monoethylene glycol plus one-fifth of annual production of surface active agents by the plant supplied to USSR. Duration of deliveries unknown.	Equipment delivery was to be completed by mid-1976.
1975	Oil additives plant	25	France United States	Speichim Standard Oil of Indiana	Speichim to provide plant design, specialized equipment and supervision. Standard Oil to provide technology developed by Amoco Chemical Corporation. Contract involves credits from French banking group.	Equipment delivery scheduled for completion by 1977.

1975	Higher fatty alcohols (equipment and technology)	48	France	Speichim	Ufa. The alcohols will be used to produce oil additives, detergents and plasticizers.	Delivery scheduled for 1977-78.
			United States	Continental Oil Company	Continental Oil will supply technology.	
1975	Petrochemical complex [3] including: Ethylene plant Propylene plant Benzene plant	 250 125 100	West Germany United States	Linde A.G. Air Products and Chemicals, Inc.	Budennovsk (Prikumsk). Houdry Division of Air Products will supply technology ("pyrotol" process) for the benzene unit. Raw material will be low octane gasoline. Possible compensation deal involving Linde purchase of unspecified Soviet products.	1977
1973	Paraxylene equipment	6 (expansion)	UK	CJB, Ltd.	Novopolotsk. The additional paraxylene will serve as feed stock for polyester fiber complex at Mogilev. Contract covers design, supervision of construction, supply of equipment and commissioning.	Equipment installation was planned for 1974.(Actual completion was in 1976.)
1973	Benzene plant	120	Italy	Eurotecnica	Ufa. Cost includes equipment and license.	January 1978
			United States	Houdry (technology and engineering design)		
1973	Benzene plant	NA	Italy	Sirce	NA	1975 (planned delivery)
1973	Acetic acid plant	150	United States	Lummus Monsanto (technology)	Severodonetsk. Raw materials to be methanol and natural gas. US Export-Import Bank loan for 45 percent, cash 10 percent, and loan from private US banks for balance. Loans to be repaid in 20 semiannual installments beginning in 1979.	1978
1972	Benzene	130	Japan	Mitsubishi Petrochemical Company Chiyoda Chemical Engineering & Construction Company Mitsubishi Corp.	Krasnodar. Loan repayment period to be five years.	NA
1972	Six compressors for ethylene plant	NA	United States	NA	Nizhnekamsk	NA

Footnotes at end of table.

USSR: Contracts For Purchase Of Chemical Equipment And Technology From Non-Communist Countries, 1971-75 *(Continued)*

Year of Contract	Type of Plant or Equipment	Production Capacity (Thousand metric tons per year)[1]	Exporter: Country	Exporter: Firm[2]	Plant Sites and Comments	Scheduled Completion Date
PETROCHEMICALS AND RELATED EQUIPMENTS[5] (Continued)						
1972	Aromatics		Japan	Kawasaki Heavy Industries	Kirishi. The US firm will provide technology and license.	1976 (actual start-up in the last half of 1976)
	Orthoxylene	60	United States	ARCO Chemical		
	Paraxylene	60	West Germany	Kali Chemie		
1971	Pyrotol unit (part of ethylene cracker)	NA	Japan		NA	NA
1971	Benzene	160	Japan	Mitsubishi Petrochemical; Toyo Engineering	Kazan. Of the total contract value, costs of technology will be about $556,000.	1976
1971	Ethylene pipeline (design, engineering and ancillary equipment)[6]	—	UK	Constructors John Brown (estimated share $15.9 million)	Pipeline to link ethylene complex at Nizhnekamsk with consuming plants at Kazan, Ufa, Sterlitamak, and Salavat. USSR will supply the pipe. CGE will supply telecommunications network and the US firm will be process coordinator. UK-guaranteed credit to be repaid over five-year period.	1974-1975 (first stage to Kazan in operation August 1976)
			France	CGE (share of contract $2.7 million)		
			United States	Phillips Petroleum		
PLASTICS, PLASTICS PROCESSING AND INTERMEDIATES						
1975	Polyurethane processing (23 installations)	NA	West Germany	Desma Group	Full contract also includes 12 molding machines for processing rubber.	NA
1975	Polyvinyl chloride plant[3]	250	West Germany	KHD Pritchard; Kloechner Industrieanlangen; Salzgitter; Chemische Werke Huls	Zima. Kloechner to provide credit financing. Huls to provide technology and Salzgitter to provide storage and shipping facilities. US firms may also participate. Suspension process will be used.	1978

1975	Thyristor drives for polyethylne and rubber processing plants	NA	UK	Brush Electrical Division of Hawker Siddeley	NA	NA
1975	Plastic laminates (10 lines)	NA	West Germany	Siempelkamp and Company Maschinenfabrik	NA	1976-77 (delivery scheduled)
1974	Polyethylene (high density plant) [3]	200	UK United States	John Brown, Ltd. Union Carbide (process technology)	Budennovsk (Prikumsk Plastics Plant). Involves a $36.6 million loan guaranteed by UK Export Credits Guarantee department. Repayment to be over eight and a half yers from date of commissioning.	1978
1974	Polystyrene plant	100	France United States	Litwin SA Cosden Oil and Chemical Company (technology)	Omsk. Estimated value of technology $2.5-$3 million. Terms: French bank credits 80 percent; cash 20 percent.	1978
1974	Vinyl chloride plant [3]	270	West Germany United States	Uhde Goodrich-Hoechst (technology)	Zima. Contract covers engineering, equipment supply, construction supervision, and commissioning. Six-year credit by Deutsche Bank. Estimated value of US technology is $550,000.	1978
1974	Injection molding machines	NA	West Germany	Demag Kunststoff-Technik	NA	1974-75 (delivery scheduled)
1974	Vinyl-coated fabric plant	20 million square feet	Japan	NA	NA	NA
1974	Plastics processing equipment	NA	West Germany	Werner and Pfleiderer	NA	1976 (delivery of equipment)
1974	Plastics processing equipment	NA	West Germany	Hermann Berstorff	To apply adhesive to laminated foil.	1975 (delivery of equipment)
1974	Film plant	5.8	West Germany	Hermann Berstorff J. H. Benecke	For production of laminated foil.	NA

Footnotes at end of table.

USSR: Contracts For Purchase Of Chemical Equipment And Technology From Non-Communist Countries, 1971-75 *(Continued)*

Year of Contract	Type of Plant or Equipment	Production Capacity (Thousand metric tons per year)[1]	Exporter Country	Exporter Firm[2]	Plant Sites and Comments	Scheduled Completion Date
PLASTICS, PLASTICS PROCESSING AND INTERMEDIATES (Continued)						
1973	Styrene-polystyrene complex[3]	—	France	Litwin SA	Shevchenko. French export credit of $80 million to be repaid over eight and a half years, beginning six months after startup. Litwin (France) will purchase 15 percent of the polystyrene for eight and a half years. The purchased polystyrene will be marketed in Europe by a UK firm and three French firms.	Initial phase end of 1977 (Revised to 1978)
			United States	Amtel		
	Styrene plant	300	France	CdF Chimie (technology)		
				Technip (technology)		
	Ethyl benzene plant	350	United States	UOP (technology)		
	Polystyrene (two plants)					
	High impact	100	United States	Emejota (process)		
	Expandable	100	France	Rhone-Poulenc (process)		
	Polystyrene panels	NA	France	St. Gobain (technology)		
1973	Polyethylene, low-density[3] (two lines)	240 total	West Germany	Salzgitter	Severodonetsk. Bochako Trading will buy part of plant's output equivalent to cost of purchased plant. This material will be sold in Western Europe. Salzgitter will provide design, procurement, and construction services.	1977: first line (revised to 1978) 1978: second line
				Imhausen (technology)		
1973	Mesh-reinforced foil (two plants)	NA	West Germany	Ewald Dorken (know-how)	The two plants will cover greatest part of Soviet requirements for mesh-reinforced foil for agriculture.	NA
			West German	Reifenhauser (engineering)		
			Denmark	Polysheet (equipment)		
1972	Polyethylene plant[3]	120	West Germany	Salzgitter Industriebau GmbH	Kazan. Five-year credit at 6-percent interest. Payment to be financed by sale of end-product outside the USSR by another West German firm	1975 (completed in late 1976)
1972	Sheet plastic (trosifol) plant	2.16	West Germany	KHD Prichard GmbH	Yerevan.	1973 (actual start up possibly 1975)

1972	Polyethylene extrusion equipment	NA	West Germany	Hermann Berstorff Maschinenbau GmbH	NA	NA
1972	31 injection molding machines	NA	West Germany	Desma-Werke GmbH	NA	Delivery during 1972-74
1972	Intermediates for production of polyurethane		France	Ensa Litwin SA	Dneprodzerzhinsk. Upjohn to provide technical data and know-how; Ensa will handle construction and Litwin-France the engineering. Crawford and Russell will supply phosgene technology. Share of US firms will be approxiately $5 million.	1974
	Polymethylene polyphenyl-isocyanate	22	United States	Upjohn Company Crawford and Russell		
	Diphenylmethane diisocyanate	5				
1972	Triacetate film plant	6	Belgium		NA	1974
1972	Isocyanate process data	NA	West Germany	Dr. Reuter-Gruppe	License for high-pressure process.	NA
1971	Vinyl chloride plant	250	West Germany United States	Friedrich Uhde Badger Co., Ltd. Goodrich	Kalush (Ukraine). Goodrich-Hoechst process to be used. Badger to supply process design and engineering.	1975 (planned and actual)
1971	Two injection molding machines	NA	West Germany	Krauss-Maffei AG	NA	1971 delivery
1971	Polyurethane foam parts	7.2 million units per year	West Germany	Maschinenfabrik Hennecke	Izhevsk (Urals)	1974-76
1971	Plastics granulation plant	NA	West Germany	Kloeckner Industrie Anlgen	NA	NA
RUBBER AND RUBBER PRODUCTS						
1975	Tire production lines				Equipment is to be installed at tire plants in Moscow and possibly Bobruysk.	NA
	Steel belted radial	3 million tires	Italy	Industrie Pirelli		
	Truck and industrial vehicle	3 million tires	UK	Dunlop Ltd.		
1975	Materials handling and storage equipment for two tire plants	NA	Italy	Fata	Bobruysk (Belorussia) and one other site.	Delivery to be completed by year-end 1976
1975	Equipment for the production of sidewalls for car and truck tires	NA	France	Zelant Gazuit	Moscow (one line) and Nizhnekamsk (two lines).	1976 (intended delivery)

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USSR: Contracts For Purchase Of Chemical Equipment And Technology
From Non-Communist Countries, 1971-75 *(Continued)*

Year of Contract	Type of Plant or Equipment	Production Capacity (Thousand metric tons per year)[1]	Exporter: Country	Exporter: Firm[2]	Plant Sites and Comments	Scheduled Completion Date
PLASTICS, PLASTICS PROCESSING AND INTERMIDIATES (Continued)						
1975	X-ray equipment for testing tires (three units)	—	West Germany	Collmann	NA	NA
1975	12 injection molding machines	NA	West Germany	Desma Group	Full contract also included 23 installations for processing polyurethane plastics.	NA
1975	Equipment for tire plant	NA	West Germany	Hermann Berstorff	Equipment to be installed at an existing tire plant in Nizhnekamsk.	Delivery in 1976
1975	Automated conveyor system for tires plant	NA	UK	Fata Ltd.	Contract involves credit of $3.38 million guaranteed by UK Export Credits Guarantee Department.	NA
1975	Mechanical handling system for tires plant	NA	UK	Fata Ltd.	Nizhnekamsk. Credit of $4.8 million guaranteed by UK export Credits Guarantee Department.	1978
1975	Rubber and rubber-to-metal bonded components for trucks	10	Italy UK	Industrie Pirelli Dunlop Ltd.	Balakovo Technical Rubber Goods Plant. Components are for 150,000 Kama trucks a year.	Equipment delivery to be completed in mid-1977
1975	Inertial testing stand for heavy-duty aircraft tires	NA	UK	Vikkers Company	NA	NA
1975	Three 1080 computer-integrated control systems for tire fabric calendars	—	United States	Measurex Corporation	NA	Installation was to be done in 1975-76
1974	Rubber mixing equipment for tire plant	NA	UK	Simon Carves	Nizhnekamsk. Includes computer-controlled automatic mill room, carbon black silo, warehouse, storage and materials handling systems. Soviet technology to be used.	1976 (equipment delivery)

1974	Tire plant	NA	West Germany	Consortium consisting of Krupp, Harburger, Buehler-Miag, Berstorff, Continental, and Pfleiderer	Possibly Bobruysk	1977
1974	Tire-retreading equipment	NA	United States	AMF Inc.	NA	NA
1973	Chloroprene monomer	75	UK	Davy Powergas Ltd. BP (technology)	Yerevan. Powergas to supply equipment	1977
1972	Machinery for rubber goods plant	NA	Italy	Pirelli Industries S.p.A.	Balakovo	NA
1972	Five compressors for butadiene plant	NA	United States	NA	Nizhnekamsk	NA
1972	Machinery for rubber goods plant	NA	Italy	Pirelli Industries S.p.A.	Balakovo	NA
1972	Tire-testing equipment	NA	UK	Redman Heenan Froude	NA	NA
1972	Two screw presses for synthetic rubber plant	NA	United States	NA	NA	NA
1971	Butadiene extraction (process license)	45	Japan	Japanese Geon Company	Nizhnekamsk	1974 (actual start-up, 1976)
OTHER CHEMICAL EQUIPMENT AND TECHNOLOGY						
1975	Adhesive application equipment	Annual capacity for applying adhesive to 6 million square meters of foil.	Austria	Wolfgang Anger	NA	Delivery to be in 1976
1975	128 chemical pumps		West Germany	Rheinhuette	For use in corrosive media.	Delivery to be in 1976
1975	Chlorofluoromethane [a] (two plants)	30 each	Italy	Tecnimont (subsidiary of Montedison)	Volgograd and Yavan. Compensation deal terms unspecified, but may include purchase of Soviet ammonia by Montedison.	1979

Footnotes at end of table.

USSR: Contracts For Purchase Of Chemical Equipment And Technology From Non-Communist Countries, 1971-75 *(Continued)*

Year of Contract	Type of Plant or Equipment	Production Capacity (Thousand metric tons per year) [1]	Exporter: Country	Exporter: Firm [2]	Plant Sites and Comments	Scheduled Completion Date
RUBBER AND RUBBER PRODUCTS (Continued)						
1975	Chromium dioxide (technology and equipment)	0.3	United States	E.I. Dupont de Nemours & Company	Shostka (Ukraine). Product to be used in making metallic particles used in audio and video magnetic tape. Sumitomo Shoji America Inc. will administer contract.	Delivery in 1976-77
1975	Equipment for production of aerosol cylinders and valves	NA	Italy	Snia Viscosa	NA	Delivery in 1976-77
1975	Equipment for recovery of toluene	NA	West Germany	Lurgi	NA	Delivery by end of 1977
1975	Four high-pressure compressors	NA	Switzerland	Burckhardt AG	For use in chemical industry.	NA
1975	High-pressure valves	NA	Austria	Bohler	For use in chemical industry.	NA
1975	Paint materials for coating metal coils (technology and lab equipment for quality control)	—	United States	H.H. Robertson	NA	NA
1975	Pumps and valves for a chlorine and caustic soda plant	—	United States	NA	Siberia	Installation was planned by late 1975
1975	Vaccine (six freeze-drying lines)	NA	UK Italy	Edwards High Vacuum Edwards Alto Vuoto	Pumps and instruments to be made by the UK firm. The Italian subsidiary will provide the freeze-dryers.	NA
1974	Chemical analysis instruments	—	United States	NA	NA	NA
1974	Chemical equipment, unspecified	—	United States	NA	Total US sales of equipment materials and products exhibited at a Soviet plastics fair amounted to $3 million.	NA
1974	Enzyme plant	NA	France United States	Nordon et Cie Rapidase Baxter Laboratories	Vinnitsa. Baxter will provide design and engineering.	1978

1974	Optical brighteners	2	France United States	Speichim Hilton-Davis	Tambov. Share of US firm will be $2.5 million for technical documentation licenses and start up assistance.	1977
1974	X-ray film plant	10.5 million m^2/year	Japan	Mitsubishi Corp. Konishiroku Photo Industry Company Ltd.	Kazan. Japanese loan to be repaid in eight annual installments at 6.5 percent.	1977 (scheduled completion of equipment supply)
1973	Chlorine-caustic soda plant	136 (chlorine) 155 (caustic soda)	Italy	Tecnimont De Nora	Sterlitamak. Tecnimont will provide salt purification and crystallization unit. De Nora to provide bulk of plant including electrolysis cells and brine treatment system, hydrogen compression units and sodium hypochlorite plant. Output will be used to produce vinyl chloride monomer.	End of 1976
1973	Chlorine dioxide plant	7.5	France United States	Krebs and Cie (engineering and equipment) Hooker (technology)	Ust-Ilim. For bleaching paper pulp. Estimated cost of US technology is $1 million.	NA
1973	Fermentation system	NA	United States	New Brunswick Scientific Company	Pilot scale, computer-coupled equipment is to be used to produce single-cell protein.	NA
1973	Twenty mixers for ink	NA	UK	Torrance and Son Ltd	NA	NA
1973	Sodium chlorate	NA	France	Krebs	Ust-Ilim. Contract covers technology and equipment.	1975-76 (delivery)
1973	Toothpaste	22.5	Italy	Pressindustria	NA	1975
1972	License for Kelfizina, a sulphonamide	NA	Italy	Montedison	NA	NA
1972	Mixing machines for pharmaceutical industry	NA	UK	Winkworth Machinery Ltd.	NA	NA
1972	Plants for production of powdered and liquid detergents, household items and glues	NA	West Germany	Henkel	NA	NA
1972	Four transfer lines for packing medicinal preparations	NA	Italy	Zanasi-Nigris	NA	NA

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USSR: Contracts For Purchase Of Chemical Equipment And Technology
From Non-Communist Countries, 1971-75 *(Continued)*

Year of Contract	Type of Plant or Equipment	Production Capacity (Thousand metric tons per year) [1]	Exporter: Country	Exporter: Firm [2]	Plant Sites and Comments	Scheduled Completion Date
OTHER CHEMICAL EQUIPMENT AND TECHNOLOGY (Continued)						
1971	Four centrifuges	NA	UK	Pennwalt Ltd.	NA	Centrifuges were to be completed by 1972.
1971	Two centrifugal methyl chloride compressors	16,000 m^3/hr	United States	NA	Nizhnekamsk	1974
1971	Technical data for manufacture of centrifugal compressors	NA	United States	NA	Compressors can be used in ammonia and methanol plants.	NA

[1] Unless otherwise stipulated.
[2] Names of firms are those in effect during contract year.
[3] Items represent purchases that involve or may involve "compensation" arrangements (that is, product buy-back).
[4] The compensation arrangement with Montedison involving the urea plant may cover Soviet purchase of a few other plants as well and may also commit Montedison to purchase Soviet urea over unspecified period.
[5] Partial listing only. Information on purchases of other petrochemical installations is included in sections on agricultural chemicals, chemical fibers, plastics, and rubber.
[6] Throughput capacity of 30 tons per hour in each direction. Length to be about 760 km.